A semi-annual report for

STUDIES OF INTERACTIVE PLASMA PROCESSES IN THE POLAR CUSP

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Submitted by:

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This is a second semi-annual report for NAGW-1657 (SwRI Project 15-2783) rather than a final report, since a no cost extension request is now in process. Several distinctly different areas of research are presently being pursued under this grant and are enumerated below.

1. Studies of the thermal structure of polar outflows:

The present emphasis on this portion of the research is the development of an interactive data analysis program for thermal ion analysis of the Dynamics Explorer/ Retarding Mass Spectrometer (DE/RIMS) data. An X-windows code to perform this analysis has recently been completed and is now in the testing phase at NASA/ Marshall Space Flight Center. A copy of the interactive display is included as Appendix A. Future work will now proceed to the analysis of DE/RIMS ion outflow data. Expected results are the composition, flux, and temperature of terrestrial ion outflows at high latitudes.

2. Prognoz data analysis:

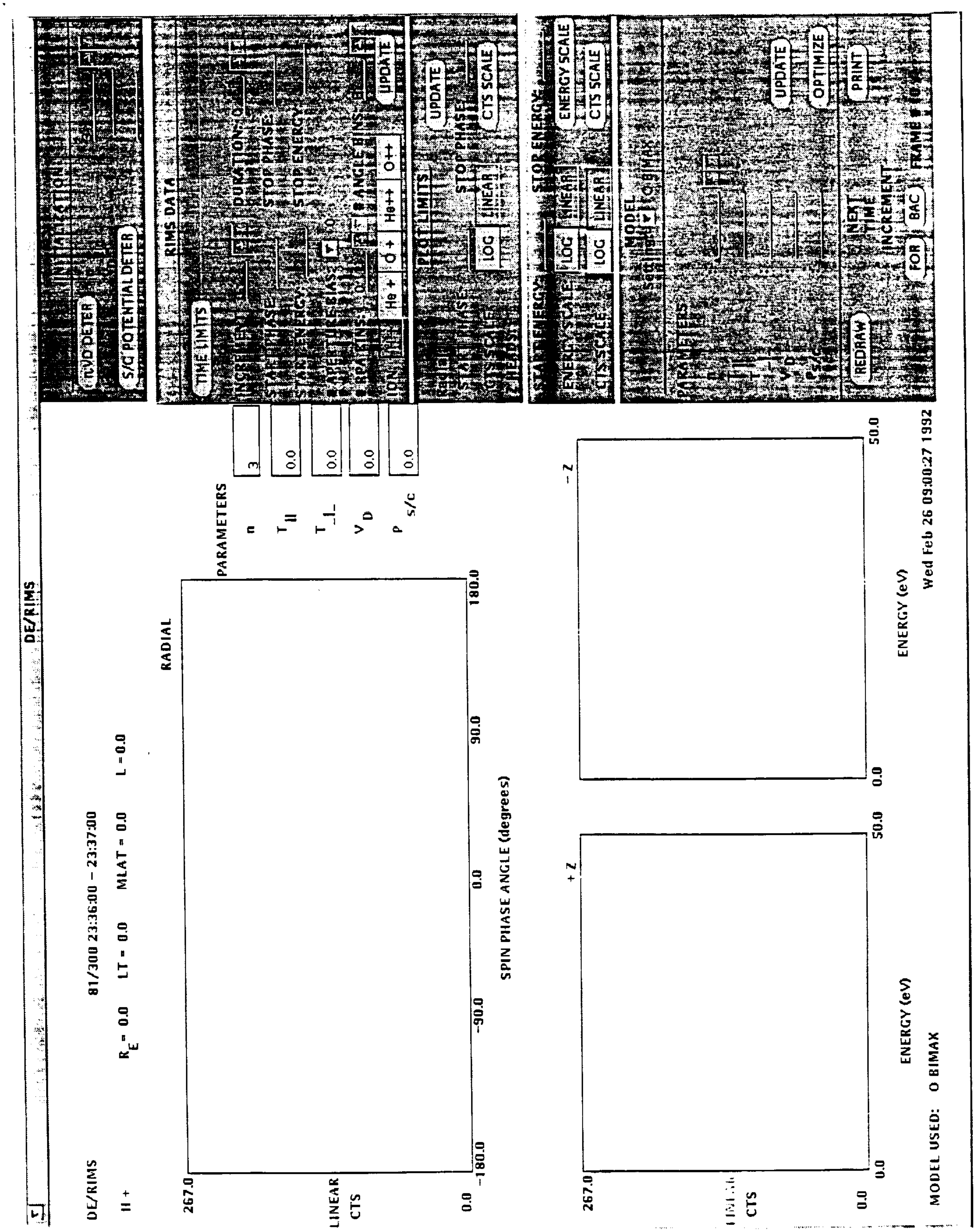
A recent visit from Dr. Oleg Vaisberg of the Russian Space Institute has provided an opportunity to examine ion and electron particle data at high latitudes over the northern polar cap which were obtained by Dr. Vaisberg's particle experiment aboard the Prognoz-8 spacecraft. Preliminary work has been begun to develop a program for subtracting the sun pulse signal from the data to allow the processing of the low intensity ion flux data in the magnetospheric lobes. From this analysis we hope to gain information about the dayside source region for the observed ion beams and to also use this data as a probe of the dynamic motion of the magnetospheric lobes. The data provide a unique opportunity, since no US mission has sampled this high latitude magnetospheric lobe region.

3. Ulysses Jupiter encounter:

A paper was presented at the annual Division of Planetary Studies of the American Astronomical Society held in Palo Alto in November of 1991 entitled "Jovian Bremsstrahlung X Rays: A Ulysses Prediction" which predicted the Jovian auroral X ray flux that should be measured by the Ulysses Gamma Ray Burst experiment during the Ulysses spacecraft's closest encounter with Jupiter in February of 1992.

The Ulysses' prediction paper generated much interest from people studying the Jovian aurora and from experimenters on the Ulysses spacecraft. As a result of this interest two things happened: 1) a paper of the same title was submitted and accepted for publication in the January issue of the Geophysical Research Letters (see Appendix B), and 2) a massive observing campaign was organized to provide supporting ultraviolet and infrared observations at the time of the Ulysses encounter. This observational interest allowed personnel at SwRI (Alan Stern, PI; Hunter Waite Co-I) to obtain director's discretionary time on the Hubble Space Telescope to support the Ulysses encounter by obtaining ultraviolet observations (see Appendix C). Once the multiple wavelength observations are obtained in February an auroral model will be used to analyze the data with hopes of providing new insight into the physical processes responsible for the Jovian aurora.

APPENDIX A



Dynamics Explorer Data Analysis Display
(Copy of CRT screen)

APPENDIX B

JOVIAN BREMSSTRAHLUNG X RAYS: A ULYSSES PREDICTION

J. H. Waite, Jr.[1], D. C. Boice[1], K.C. Hurley[2], S.A. Stern[1], and M. Sommer[3]

Abstract. The Jovian aurora is the most powerful planetary aurora in the solar system: to date, however, it has not been possible to establish conclusively which mechanisms are involved in the excitation of the auroral emissions that have been observed at ultraviolet, infrared, and soft X ray wavelengths. Precipitation of Iogenic heavy sulfur and oxygen ions, downward acceleration of electrons along Birkeland currents, and a combination of both of these mechanisms have all been proposed to account for the observed auroral emissions. Modeling results reported here show that precipitating auroral electrons with sufficient energy to be consistent with the Voyager UVS observations will produce bremsstrahlung X rays with sufficient energy and intensity to be detected by the Solar Flare X Ray and Cosmic Ray Burst Instrument (GRB) on board the Ulysses spacecraft. The detection of such bremsstrahlung X rays at Jupiter would provide strong evidence for the electron precipitation mechanism, although it would not rule out the possibility of some heavy ion involvement, and would thus make a significant contribution toward solving the mystery of the Jovian aurora.

Introduction

The identity of the precipitating particles involved in Jovian auroral activity is still an open question. In situ observations of the Jovian particle populations during the Voyager 1 and 2 encounters furnished evidence for changes in the radial phase space distribution of energetic heavy ions which are best explained by ion precipitation [Gehrels

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and Stone, 1983]. However, the energy range of the ion measurements did not go low enough to demonstrate that heavy ion precipitation could provide the power input required to explain the ultraviolet emission intensities. Voyager provided no in situ evidence for electron precipitation; however, indications of electron acceleration in Birkeland currents connected to the auroral zone would only be observable at high latitudes closer to the planet, a region not accessible to the Voyager spacecraft.

Remote sensing observations also present a mixed picture. Soft (0.3-3.0 keV) X ray observations of the Jovian aurora by the Einstein observatory [Metzger et al., 1983] have been used to argue for heavy ion precipitation. The energy resolution of the Einstein X ray observatory was not sufficient to distinguish between a bremsstrahlung power law distribution and K-shell emission line spectra from sulfur and/or oxygen. However, based on modeling the K-shell and bremsstrahlung mechanisms and their response within the Einstein telescope, Metzger et al. [1983] inferred that the energy required to produce the observed soft X ray emission by means of electron bremsstrahlung was unreasonably large compared with that required by the K-shell mechanism and thus argued in favor of heavy ion precipitation as the source of Jovian auroral X rays. This conclusion has been substantiated by the recent electron bremsstrahlung calculations of Waite [1991]. On the other hand, attempts at observing extreme ultraviolet emissions from sulfur and oxygen precipitation were unsuccessful [Waite et al., 1988] and suggested that, although heavy ion precipitation may indeed be the source of the soft X rays, heavy ions may not have sufficient energy flux to account for the bulk of the H_2 ultraviolet emissions observed by Voyager [Broadfoot et al., 1981] and IUE [Livengood et al., 1990].

Indeed, the H_2 Lyman and Werner band emission intensities and spectral characteristics of the ultraviolet emissions can be used to set constraints on both the energy flux and energy distribution of the precipitating particles [Livengood et al., 1990]. In this paper these constraints are used in conjunction with modeling techniques to predict the hard X ray fluxes that are expected to be detected at Jupiter by the Solar Flare X Ray and Cosmic Ray Burst Instrument (GRB) as Ulysses makes its closest approach in mid-February of 1992.

Model

The auroral electron distributions as a function of altitude and energy are found by using a two-stream electron transport code modified for Jupiter [Waite et al., 1983] and extended to electron energies of 2 MeV using the relativistic H_2 cross sections of Garvey et al. [1977]. The differential bremsstrahlung cross sections were taken from the work of Koch and Motz [1959] (formulae 3BN and II-6). X ray atmospheric absorption effects were calculated, but were less than 10% at all photon energies above 100 eV for all primary electron beam energies considered. The electron transport model also calculates the electron-induced H_2 ultraviolet band emissions using the most recent cross sections of Ajello et al. [1988] and Shemansky and Ajello [1988] with the most recent corrections for absolute laboratory reference calibration [R. Gladstone, private communication, 1991].

The model also solves the one-dimensional chemical diffusion equations for atomic hydrogen and the hydrocarbon species CH_4, C_2H_2, C_2H_4, C_2H_6, and CH_3, and the major ion species H^+ and H_3^+. The neutral temperature structure adopted in the present study is an equatorial profile determined from the Voyager ultraviolet spectrometer (UVS) occultation experiments [Festou et al., 1981]. Although auroral energy input is expected to modify this profile, there is at present limited information as to the effects of this input. Furthermore, increases in the auroral thermal structure produce little change in the calculations apart from changes in the relative altitude of the atmosphere. The hydrocarbon density profiles used in this model are consistent with the recent work of Gladstone et al. [1991] and use an eddy diffusion coefficient of 2 x 10^6 cm^2 s^{-1} at the methane homopause.

The characteristics of the H_2 Lyman and Werner band spectra observed in Jovian auroral emissions are significantly affected by methane and acetylene, which absorb differentially over the H_2 band's spectral range. The measure of this differential absorption is the color ratio, which Livengood et al. (1990) have defined as the ratio of the integrated intensities (I) of two wavelength bands: I(1557-1619Å)/I(1230-1300Å).This ratio can be used to infer the methane column density above the region of peak H_2 band emissions: since methane is a strong absorber in

the wavelength range 1230 to 1300Å and not in the range 1557 to 1600Å, a high color ratio indicates a large column abundance of methane. The methane absorption effects are related to the H_2 vertical distribution through the specified eddy diffusion coefficient and thermal structure. Electron energies used in the model to determine bremsstrahlung X ray fluxes are chosen by inputting electron beams into the assumed model atmosphere and then selecting the ones that fit to the observed color ratios for CH_4 absorption.

Uncertainty in determining the primary electron beam energy is introduced by assuming that the equatorial and auroral regions of the atmosphere have the same vertical structure. The present uncertainty hinges on our lack of knowledge about the high-latitude methane vertical structure and for the present we simply use the measured near-equatorial structure inferred from Voyager UVS measurements [Festou et al., 1981]. However, we note that if Ulysses determines a bremsstrahlung X ray photon energy spectrum then it will provide an independent constraint on the precipitating electron energy distribution. Simultaneous ultraviolet observations of the color ratio by an ultraviolet observatory (such as HST) would thereby not only allow us to check our modeling assumptions, but would provide unique information on the polar auroral atmosphere.

Anticipated Ulysses GRB Observations

The GRB instrument on Ulysses consists of two hemispherical shell CsI scintillators coupled to phototubes for measuring X rays in the range of 20 to 150 keV, with time resolution up to 8 ms. A detailed description of the instrument can be found in Hurley et al. [1992]. We have calculated the Ulysses sensitivity to Jovian X rays from data accumulated over the first year of operation. During solar quiet periods, which are characteristic of the majority of the mission, the 18-100 keV background rate of each detector is around 200 counts/second; this arises primarily from the diffuse cosmic X ray background and the Radioisotope Thermoelectric Generator aboard the spacecraft. Using the corresponding count rates in the individual energy channels, and assuming a 100 minute integration, we obtain the 3 sigma sensitivities given in Table I and shown in Figure 2.

The closet approach of the Ulysses spacecraft to Jupiter will occur on February 8th of 1992. The spacecraft will approach Jupiter over the north polar cap. pass through perijove near 6.3 R_J, and exit the Jupiter system over the southern polar cap. Although Jupiter's trapped energetic particles will preclude observations near the equator. observations over the north and south poles will be possible before and after closet approach.

Results

Model H_2 band calculations have been matched to the statistical information concerning ultraviolet emission intensity and color ratio determined by ten years of IUE observations [Livengood et al., 1990], and the flux and energy distribution of the incoming electrons have been calculated. These calculated electron beams have been used to compute bremsstrahlung X ray fluxes, which serve as the predictive data set for the Ulysses GRB observations.

The specification of the precipitating electron spectrum is of the form $J(E)=J_{op}(E/E_{op})\ \exp(-E/E_{op})$, where the parameter J_{op} specifies the differential flux ($cm^{-2}\ s^{-1}\ keV^{-1}$) and E_{op} the characteristic energy (keV) of the precipitating electrons. Since the IUE observations show that both the intensity and the color ratio are strong functions of the S_{III} longitude. we have modeled these observations using three independent sets of primary electron parameters which correspond to ultraviolet observational values at 0, 150. and 180 degrees S_{III} longitude in the northern auroral zone (NAZ). The electron beam parameters and the associated ultraviolet characteristics are given in Table II for the three cases. The color ratio has been calculated at two zenith view angles. 0 and 60 degrees. The effect of doubling the hydrocarbon density (60° zenith view angle) results in a 11 to 19% increase in the color ratio due to differential methane absorption, as discussed above. The calculated variance of the color ratio illustrates the sensitivity of the calculation to the view angle of the ultraviolet observation and gives some idea of the sensitivity of the calculation to the chosen model atmosphere. Values of the H_2 band intensity and color ratio for the three cases have also been spline-fit to produce a model curve which can be compared to the Livengood et al. [1990] IUE observations. The results of that fit are shown in Figure 1. In Figure 1(a),

auroral H_2 band intensities have been integrated over the restricted spectral range 1557-1619Å (a rough comparison of this restricted intensity/wavelength integration to the total integrated H_2 Lyman and Werner band intensity given in Table II can be obtained by multiplying by 9.1). The fit appears quite good apart from a phase shift of the color ratio in S_{III} longitude: this could be removed by adjusting the characteristic beam energy, E_{op}, a process not warranted given the present uncertainties of the auroral atmosphere. A likely explanation for this effect is that the time-dependent, atmospheric composition is modified by the precipitating electrons, leading to a characteristic lag in S_{III} longitude of the peak hydrocarbon absorption.

Finally, the X ray fluxes that result from the two extreme electron precipitation cases (case 1: 0 to 120 degrees S_{III} longitude in the NAZ and case 3: 180 degrees S_{III} in the NAZ) are shown in Figure 2. The X ray intensity as a function of photon energy is plotted for an auroral zone emission size 5000 by 10,000 km observed from a distance of 10 R_J. Also plotted on the figure is the sensitivity of several of the GRB energy channels for similar viewing conditions and an integration period of 100 minutes.

Conclusions

The results plotted in Figures 1 and 2 indicate that if the ultraviolet auroral emissions are due to precipitating electrons and the Jovian aurora is sufficiently active (this must be determined by simultaneous EUV observations which will be carried out by the Hubble Space Telescope), then the Ulysses GRB experiment should be able to measure the bremsstrahlung X ray spectrum and place firm constraints on both the precipitating electron flux intensity and energy spectrum. Furthermore, observed S_{III} longitude variations in the spectrum can be used in conjunction with the ultraviolet intensity and color ratio values from HST to determine the vertical hydrocarbon structure in the polar stratosphere of Jupiter. On the other hand, if the major precipitating particles are heavy ions, then GRB would detect nothing since its lowest energy channel at 20 keV is above the threshold for both sulfur and oxygen K-shell emissions.

Acknowledgments. Partial support for this work has been provided by NASA Planetary Atmospheres grant NAGW-1657, NASA IUE and ROSAT Observations of Jupiter's Aurora grant NAG5-1429, and by SwRI Internal Research project 15-9634. The Ulysses project is supported in the United States under JPL Contract 958056 and in Germany by FRG contracts 01 on 088 ZA/WRK275/4-7.12 and 01 on 88014.

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Fig. 1. (a) Intensity and (b) color ratio distribution of the H_2 extreme ultraviolet (EUV) auroral emissions. In Figure 1(a) the H_2 EUV emission intensity in kilorayleighs is integrated over the range 1557-1619 Å. In Figure 1(b) the intensity in the wavelength range 1557-1619 Å has been divided by the intensity in the wavelength range 1230-1300 Å. In (b), the dashed line is the color ratio value for an unattenuated spectrum of H_2 excited by impact of 100-eV electrons: points below this line are plotted as diamonds. The crosses represent the median error bars in longitude and intensity/color ratio for the 60° width centered on each cross. The uncertainty in intensity and color ratio is computed from the camera noise level. The error bars shown here do not include any estimation of possible systematic error as a consequence of erroneous subtraction. The solid lines in both figures are the present model results.

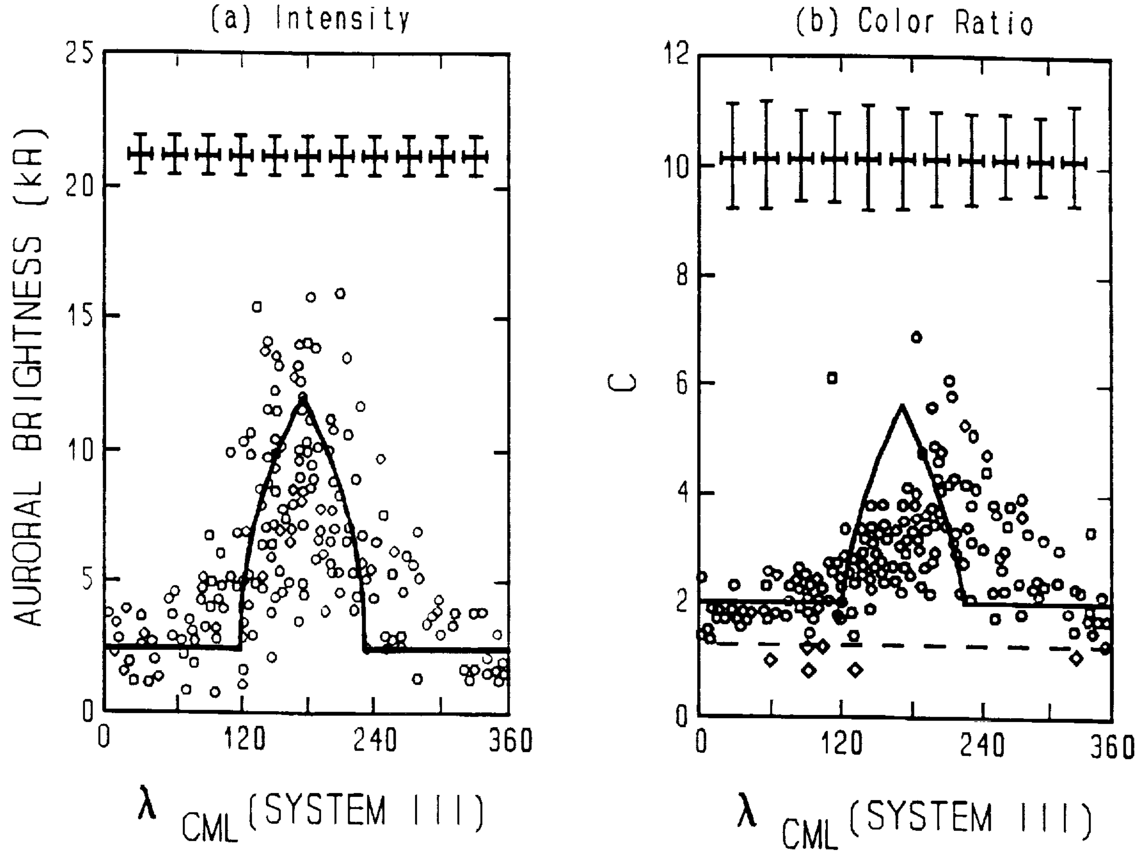
Fig. 2. The X ray intensity as a function of photon energy for a Jovian auroral source size of 5000 by 10.000 km: viewed from a distance of $10R_J$. The solid bars marked 1-5 indicate the 3 sigma sensitivities of the five lower GRB channels for a 100 minute integration.

TABLE I. Ulysses GRB Sensitivities

Channel No.	Energy Channel (keV)	Sensitivity (Photons cm^{-2} s^{-1} eV^{-1})
1	18.1 - 31.1	9.8×10^{-7}
2	31.1 - 43.5	1.0×10^{-6}
3	43.5 - 56.0	9.3×10^{-7}
4	56.0 - 68.4	7.7×10^{-7}
5	68.4 - 80.9	6.2×10^{-7}

TABLE II. Model Parameters and UV Properties

	S_{III} Longitude (degrees)	E_{op} (keV)	Energy Flux (erg cm^{-2} s^{-1})	H_2 Bands (kR)	Color Ratio (zenith angle)
Case 1	0	20	2.8	21.9	1.98(0°) 2.20(60°)
Case 2	150	37	9.8	83.2	4.17(0°) 4.92(60°)
Case 3	180	45	12.1	105.1	5.43(0°) 6.47(60°)



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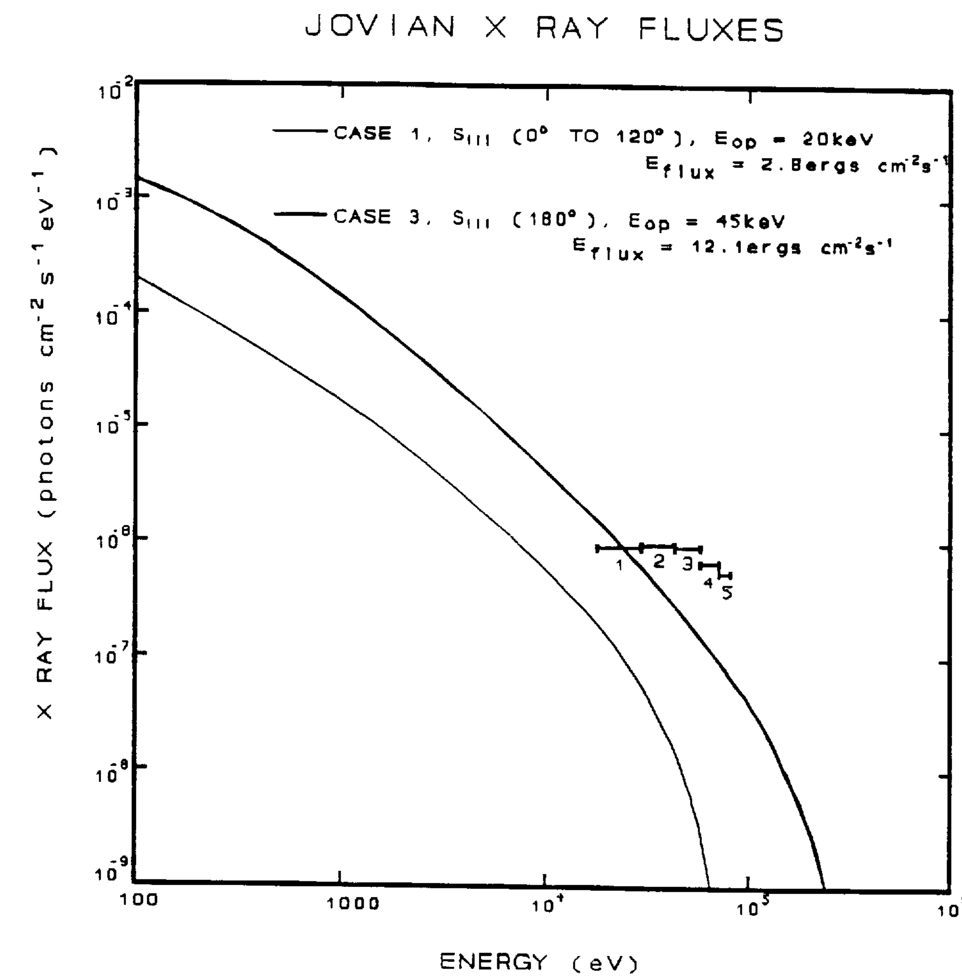

Figure 2. The X ray intensity as a function of photon energy for a Jovian auroral source size of 5000 by 10,000 km; viewed from a distance of $10R_J$. The solid bars marked 1-5 indicate the 3 sigma sensitivities of the five lower GRB channels for a 100 minute integration.

APPENDIX C

SOUTHWEST RESEARCH INSTITUTE

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INSTRUMENTATION AND SPACE RESEARCH DIVISION

22 November 1991

Dr. Riccardo Giacconi, Director
Space Telescope Science Institute
3700 San Martin Drive
Baltimore, MD 21218

Dear Dr. Giacconi:

We are writing to request Director's Discretionary Time for HST UV imaging of Jupiter in conjunction with the Ulysses Jupiter flyby on 8 February 1992. Our request totals 1.6 hours of observation time. To our knowledge, no HST or IUE observations of Jovian aurora are planned for this time, even though (as we describe below), a crucial opportunity exists for collaborative studies utilizing HST's UV and Ulysses' x-ray capabilities.

Owing to the press of time, Bruce Gillespie of the STScI USB has encouraged us to send this letter as our formal request, rather than taking the time to complete the full suite of Phase I forms. A Phase I Observation Summary Form detailing the proposed observations is attached to this letter. We are calling this proposed DD program, "HST Imaging of Jupiter to Support the Interpretation of Ulysses X-ray Aurora Measurements: Establishing the UV Auroral Output." If approved, we are prepared to immediately submit a Phase II electronic proposal.

The UV observations proposed here are focused on making a single observation needed to understand the production of x-rays in the Jovian aurora. The critical issue in Jovian x-ray production is whether they are electron bremsstrahlung- or precipitating ion-generated. As described below, near-simultaneous UV and x-ray measurements are required to resolve this issue.

Ulysses is carrying an x-ray/γ-ray detector called GRB (Hurley, et al. 1992), which will be making the first measurements of x-ray production from within the Jovian system. Owing to its proximity to Jupiter, GRB will provide increased 20-150 KeV sensitivity over that made by earth-orbiting x-ray observatories. Ulysses will approach Jupiter in the ecliptic, fly over the northern polar cap, pass through perijove at 6.3 R_J (near Io's orbit), and exit over the southern polar cap (see Figure 1). GRB will study both auroral zones. Ulysses' flyby geometry and proximity will allow GRB to provide the best observations of Jovian x-ray spectra to date.

The relationship of auroral UV and x-ray production has been an active area of research since the first detection of Jovian x-rays by the Einstein observatory (Metzger, et al. 1983).

Observations of auroral emissions at UV and soft x-ray energies have since revealed that the Jovian system contains the most powerful planetary aurora in the solar system, with an output of $> 10^{13}$ watts. However, the identity of the precipitating particles, and the mechanism for energizing them, are major open issues.

On the one hand, in situ measurements of Jovian particle populations during the Voyager 1 and 2 encounters detected changes in the radial phase space densities of energetic S and O ions best explained by ion precipitation (Gehrels and Stone 1983). Yet the ion energy flux detected by Voyager was not sufficient to explain the observed UV aurora. Although soft (0.3-3.0 keV) x-ray observations of the Jovian aurora by Einstein have been used to argue for heavy ion precipitation, attempts at observing UV emissions from S and O ion precipitation have been unsuccessful. This has led to the suggestion that electron precipitation may instead be the dominant source mechanism (Waite, et al. 1988).

The Ulysses mission is the only planned flight of an x-ray instrument to Jupiter. *Therefore, the February 1992 encounter represents the only forseeable opportunity to make UV measurements of the Jovian aurora when an in situ spacecraft is making coordinated x-ray observations and monitoring the charged particle input.* The fact that the Ulysses measurements will be made *over* the polar auroral regions adds to our excitement about this opportunity. In essence, this flyby— which is now barely 10 weeks away— appears to be the only time in the next decade during which a complete set of Jovian x-ray, UV, and charged particle measurements can be obtained. (An AXAF x-ray/HST UV/Galileo charged particle collaboration may be possible in ≈10 years if Galileo is operating when AXAF flies, but this is only speculation).

Sensitivities for a 3-σ detection and 100 minute integration have been calculated for the five lowest energy channels of the GRB instrument. They are plotted in Figure 2, along with the results of model calculations (Waite, et al. 1991) which give the predicted auroral x-ray energy spectrum. This figure shows that the GRB experiment should be able to measure the predicted x-ray spectrum if electron brehmsstrahlung is the dominant source mechanism. However, it has become increasingly clear that the results of the Ulysses GRB experiment will be ambiguous unless the total power of the aurora is known. Without this measurement, the curve on Figure 2 for the *actual* observing conditions Ulysses sees cannot be determined. As such, the Ulysses experiment lacks the key auroral energy measure.

This situation can be remedied by HST because the UV Lyman and Werner band H_2 auroral emissions are the best known measure of the flux and energy distribution of the precipitating particles (cf. Livengood, et al. 1990 for a discussion of Voyager UVS and IUE results).

Our request for Director's Discretionary Time to measure these emissions with HST is limited to obtaining a straightforward set of FOC f/96 UV images. These images will allow us to meet two objectives. They are:

- *To determine the extent and variability of the Jovian UV aurora coincident with the Ulysses charged particle and x-ray measurements.* And,

- *To estimate the total UV power output using models which compute the total auroral UV emission from Werner band emission alone (e.g., Waite, et al. 1991), and relate this to the Ulysses-derived x-ray power spectrum (cf. Livengood, et al. 1990).*

The proposed experiment protocol is to make four images of Jupiter using the f/96 chain with filters F130M and F140W in series. The F130M filter contains our key H_2 band (and some contribution from Lyα, which can be modelled from the observations). The F140W filter is used to drastically reduce effects of red leaks of planetary albedo in the image, thereby increasing the contrast of the aurora. If we adopt zoomed pixels (z=2), exposure times of 39 minutes should yield an S/N of 9-11 in each 1 arc-sec resolution element within an auroral emission region with an H_2 brightness of 5 kR. The H_2 emission could be much brighter, perhaps 15 kR. However, even at 5 kR this exposure time is sufficient to meet the objectives outlined above.

Of the four images, we request two be made during Ulysses' inbound passage and two during the outbound passage. These images should be made during ~10-12 hour windows on either side of Ulysses' closest approach (more optimal times within these windows can easily be predicted for the Phase II submission based on sub-earth Jovian System III longitudes). As Ulysses makes its approach, we propose to image both polar auroral zones with the FOC; at this time GRB will also be observing both zones. As Ulysses makes its departure, we propose to image the southern auroral zone twice more: at this time GRB will be viewing only the southern auroral zone. Together, the three southern zone images will allow us to gauge the variability of the southern aurora during the GRB integrations. The single northern zone image during Ulysses' approach will allow us to compare the auroral UV/x-ray correlation between hemispheres. Our preference for southern zone observations is driven by the Ulysses trajectory and GRB observing plan.

Using the RPSS resource estimator algorithm, we calculate that each of the four requested exposures will require 54.5 minutes of spacecraft time. *In toto*, we are therefore requesting 3.63 hours of spacecraft time to complete the four auroral imaging observations, with a program efficiency of 72%. As a fallback, the minimum viable experiment would consist of two observation sets, one each as GRB observes the north and south auroral zones. This would cut the required spacecraft time essentially in half. However, we stress the importance of multiple measurements in the south in order to determine the variability of the UV auroral emissions during this one-and-only Ulysses flyby.

Our proposal team consists of five experienced observers and a leading Jovian auroral modeller. The team has almost thirty years of Jovian auroral observing and modelling experience. Three of us have been deeply involved in HST GO and GTO observations. Two of us (Hurley and Sommer) are US and European PIs on the Ulysses GRB x-ray instrument.

No spacecraft observatory but HST can make UV measurements of Jupiter during the critical Ulysses flyby opportunity. ASTRO will not be flying. IUE cannot observe due to geometry

i.e., β-angle) constraints which HST does not suffer. Galileo will be too far away (6 AU) to accomplish a detection. If collaborative UV/x-ray measurements of Jupiter's aurora are to be obtained during this unique encounter, HST must perform them.

We look forward to hearing from you concerning this request.

Sincerely,

Alan Stern

Co-I's:

Dr. Kevin C. Hurley (UC Berkeley)
Dr. Melissa A. McGrath (Johns Hopkins Univ.)
Dr. Michael Sommer (Max Planck EP/Garching)
Dr. Laurence M. Trafton (U. Texas/Austin)
Dr. Hunter J. Waite (Southwest Research Institute)

xc: Bruce Gillespie/STScI, Chief USB
Nolan Walborn/STScI, Head SPS

Enclosures:
Figures (2)
Observation Summary Form
Preprint (Waite, et al. 1991)

References

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Table I ULYSSES GRB SENTITVITIES

Channel No.	Energy Channel (keV)	Sensitivity (Photons cm^{-2} s^{-1} ev^{-1})
1	18.1 - 31.1	9.8×10^{-7}
2	31.1 - 43.5	1.0×10^{-6}
3	43.5 - 56.0	9.3×10^{-7}
4	56.0 - 68.4	7.7×10^{-7}
5	68.4 - 80.9	6.2×10^{-7}

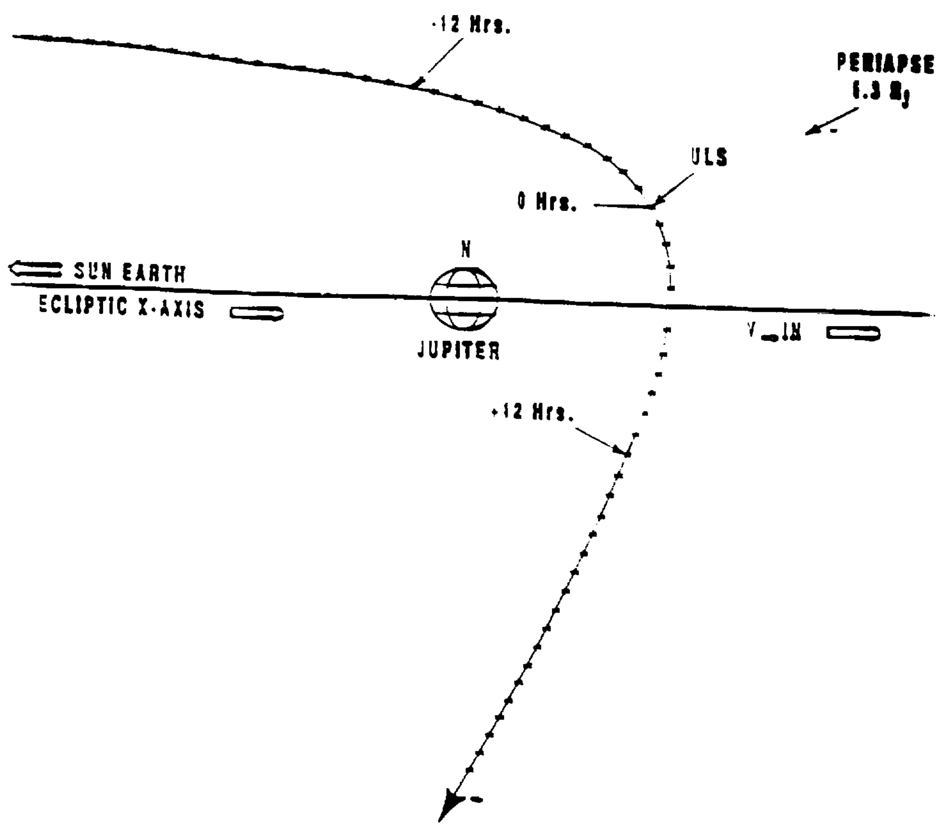

Figure 1 Trajectory Equatorial View at Jupiter

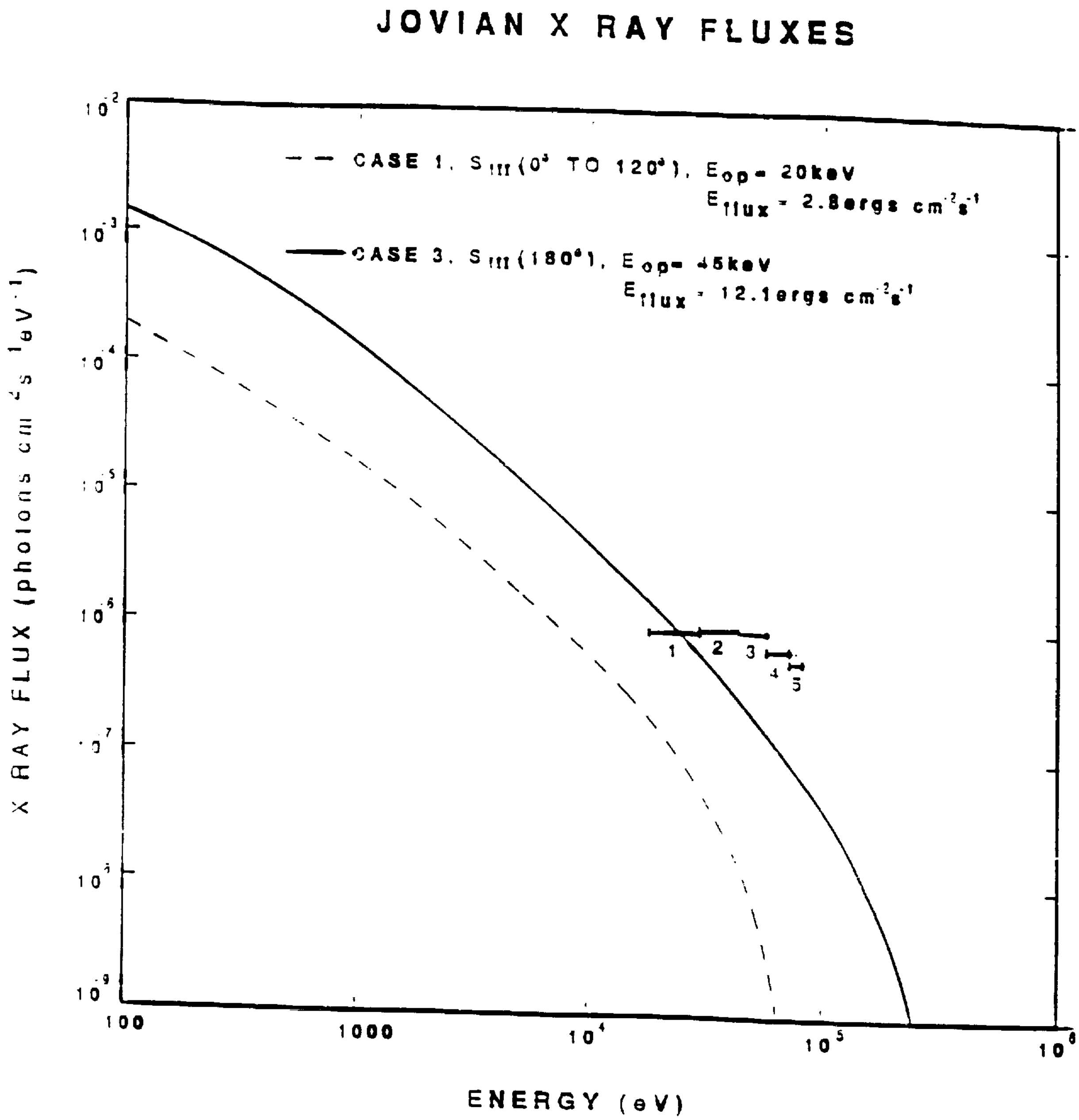

Figure :. The x ray intensity as a function of photon energy for a Jovian auroral source 5000 by 10,000 km and viewed from a distance of $10R_J$. The solid bars 1-5 indicate the 3 sigma sensitivities of the five grp energy channels for a 100 minute integration.

HUBBLE SPACE TELESCOPE
CYCLE 2 PROPOSAL

OBSERVATION SUMMARY FORM

1	2	3	4	5	6	7	8
LINE# #.0 #.1 #.2	TARGET NAME (TARGET (DESCRIPTION)	RA (H,M,S) DEC (D,',") (EQUINOX)	MAG B-V	INSTRUMENT MODE	SPECTRAL ELEMENTS	TIME #EXP	SPEC. REQs.
1.0 1.1	JUPITER-NORTH (PLANET)	SS:PLANET	-2.5	FOC/96 IMAGE	F130M+F140W	39M 1	OA=1 NV=1

!COMMENTS: 11 X 11 ARCSEC FOV POINTED AT JUPITER'S NORTH POLAR REGION
!COMMENTS: ZOOM=2, 16 BIT DYNAMIC RANGE
!COMMENTS: 1 ARCSEC IMAGING RESOLUTION REQUIREMENT PERMITS COARSE LOCK

2.0 2.1	JUPITER-SOUTH (PLANET)	SS:PLANET	-2.75	FOC/96 IMAGE	F130M+F140W	39M 3	OA=3 NV=3

!COMMENTS: 11 X 11 ARCSEC FOV POINTED AT JUPITER'S SOUTH POLAR REGION
!COMMENTS: ZOOM=2, 16 BIT DYNAMIC RANGE
!COMMENTS: 1 ARCSEC IMAGING REQUIREMENT PERMITS COARSE LOCK

!COMMENTS:
!COMMENTS:
!COMMENTS:

!COMMENTS:
!COMMENTS:
!COMMENTS: